ROYAL ASTRONOMICAL SOCIETY.

VOL. XV. *March* 9, 1855. No. 5.

M. J. JOHNSON, Esq. President, in the Chair.

J. B. Dancer, Esq., Manchester ;
Wentworth Erck, Esq., 27 Herbert Place, Dublin ; and
R. J. Mann, M.D., 7 St. Boniface Terrace, Ventnor,

were balloted for and duly elected Fellows of the Society.

Death of Professor Gauss.

A letter was read from M. Hausmann, Secretary of the Royal Society of Sciences of Göttingen, announcing the death of this distinguished individual, on the 23d ultimo, in the seventy-eighth year of his age.

Account of Operations connected with the Advancement of Commercial Astronomy in Australia. By Robert L. J. Ellery, Esq.

(*Extracts of a Letter to the Astronomer Royal.*)

" Although not a member of the Astronomical Society, I take the liberty of communicating to you, as President of that body, the following information, deeming that the interest felt by the Society in the progress of science may prove a sufficient excuse for addressing them on so trivial a matter.

" In June 1853, a time-ball signal—visible to the shipping in Hobson's Bay—was erected on the mast or flagstaff, Gellibrand's Point. Soon after its erection, I was appointed to take the necessary observations for the regulation of this signal. At that time, two chronometers (neither of them first-class instruments), and two indifferent sextants, with a small artificial horizon, composed the staff of instruments. By using the system of equal altitudes on every possible opportunity, I ascertained the rate of one chronometer to be sufficiently reliable to enable me to give the time,

even through a few days of cloudy weather; but the sudden and great changes of temperature act as a severe test to a chronometer's performance.

"In August, a small transit instrument was offered for sale, and bought by Government, with the works of a new regulator clock by Evans of Birmingham. Authority was given me to get a room built for the instrument and clock, which was done, attached to my quarters. The instrument was one of Spencer and Browning's 23-inch, on iron stand. Having some fine stone close at hand, I got some blocks cut, and a very substantial pier built. The building being of wood, the foundations for both transit-pier and clock had to be quite free from the building. The works of the clock were put in a case I got made here, and was mounted on a stone pier, built up about an inch above the level of the floor, with a large plank as a support at the back, built in with the foundation. The room had its meridional opening from horizon to horizon,—the south opening having a sea horizon, the north highlands at the back of Melbourne. After much trouble in adjusting the transit from the constant settling of the pier, from bad cement having been used, I got it into working order: got up a meridian mark, about half-a-mile away, consisting of three parallel vertical lines, finely marked with black paint on a white ground; and after that it soon became so steady as to only require occasional levelling. The clock, whose compensation was the mercurial one, after some little trouble, went very well and steadily in all the great extremes of temperature we are subject to (the temperature often has varied 45° from noon till midnight).

"With these instruments the time-signal has been given daily, Sundays excepted, up to February 1854, when a few instruments which had been ordered by the Colonial Government arrived, consisting of 30-inch transit by Potter (late Bates), regulator-clock, mercurial pendulum by Frodsham, sextant by Potter. These instruments were put into use at once; a new pier with a broader foundation was built for transit, and the old clock was removed to a room we use for chronometer-room, where a great many chronometers are brought for rating, &c. Up to this present time no other addition has been made, with the exception of one or two plain meteorological instruments. The clock by Frodsham is performing beautifully, having a steady rate of $-0^{s}\cdot3$ a-day, with scarcely any perceptible deviation for temperature. Several times I have noticed, when the barometer was at 30·20—30·25, a little more loss; but on the whole it has performed exceedingly well. The work that I have done with these instruments is as much as could be well done. The time-keeping is, of course, the main object at present; but, in addition, I am tabulating a regular list of zenith and circumpolar stars (of course of right ascension only, as the instrument has only a setting circle reading to minutes). I have, I think, determined the longitude of the observatory pretty closely, from the mean of

35 sets of moon-culminations. Its previously assigned position was $9^h\ 39^m\ 41^s{\cdot}8$ E., 37° 52′ 42″ S.; but I make the longitude, $9^h\ 39^m\ 40^s{\cdot}0$ by the mean of 35 culminations. The assigned latitude I have always found correct. The previous position was, I believe, given by Captain Stokes, of one of her majesty's surveying vessels.

"The time-ball is a frame-work ball covered with canvass painted black, and is hoisted to the masthead by halyards, which halyards, when the ball is hoisted, are attached to a trigger below, and by a slight pull on which the halyards are released the ball drops. It is rather a primitive arrangement, but answers pretty well. Since the chief station of the electric telegraph has been completed at Melbourne, a time-ball has been placed on the tower of that building for the benefit of the city of Melbourne, and it is dropped at the same instant as the one here by means of the telegraphic wire. As yet no coil magnets are used for releasing the detents, as we have not been able to get them made yet; but I am only now waiting for authority to get the connexion as complete as possible. As it is now, I have to take a previously compared chronometer to the Flagstaff, a distance of about 50 yards from the observatory, and by the side of the trigger of the time-ball is a little brass *circuit closer* (the whole line being in complete circuit from 5 minutes to 1 o'clock, except at the Flagstaff, where the signal is given from). The ball in Melbourne being hoisted at the same time it is here—3 minutes before one—I connect the circuit several times to see all is right; each connexion is made known to the telegraph operator in Melbourne by the deflexion of a small needle indicator; he then stands in readiness with his hands on the trigger, and 5 seconds before one—I give seconds beats of the indicator—by connecting each second at the fifth beat both balls are released; and, from repeated watching, no perceptible interval in their dropping is perceived. The time-balls are about 8 miles apart: the one in Melbourne is a little to the eastward of the observatory, —about 2 seconds' time, I think. The exact instant of the drop of the Williamstown time-ball is marked by my only assistant, my wife; and if any error occurs, from wind or otherwise, it is thus accurately accounted for, and published in the daily papers.

"It is proposed to erect time-balls on the electric telegraph stations, which are now in course of erection at Geelong and Port Phillip Heads, so as to make every use of the observatory possible in giving mean time to different parts of the colony. The plan for these time-balls I have given myself, and will be constructed so as to be dropped by direct galvanic current without any manual intervention; and I wish to adopt the same means that you have done with regard to the time-ball at Deal (I think it is Deal),—viz. an apprisal by the drop of the signals themselves that they have dropped correctly. In addition to time-balls here, since June last another means has been adopted as a time-signal,—viz. the light of the lighthouse on Gellibrand's Point. It having been

represented to the chief harbour-master that on account of the great crowd of shipping those lying towards the opposite shores could not see the time-ball, and begging that some means might be adopted to make the signal more generally seen, the harbour-master had an apparatus fitted to the inside of the lantern, which obscures the light by releasing one trigger, and shows it again suddenly by releasing another. This was his own arrangement, and my instructions were to obscure the light at 2 minutes to 8 P.M., and suddenly show it at 8 o'clock, the latter being the true signal, any error of which would be published in the daily papers. It answers very well, but is very inconvenient, climbing the lighthouse-tower with a chronometer in hand. The master-mariners think it a great convenience, as it allows them to attend to the rating of their chronometers themselves, for business often keeps them on shore during the day. If this is continued, I must get some better plan devised: the telegraph wires could be used here too.

"The sum of 2500*l.* was voted by the Legislative Council for the building a stone observatory at Williamstown; this has not been done yet, but the Governor has placed in the estimates for next year the sum of 660*l.* for the purchase of astronomical and meteorological instruments, according to a list of what would absolutely be required that I was instructed to send in. The chief of these instruments were,—a transit circle, by Troughton and Simms; a 5 or 6-feet equatoreal by Troughton and Simms, or Ross; a portable transit collimator, &c.; with a small equipment of good meteorological instruments. In the ultimate purchase of these instruments, perhaps you might give some advice, from your great experience in such matters. At all events, I shall take the liberty of informing you when the orders are sent home for these instruments, in case you might feel any interest in guiding the purchase of them. I had omitted to say, that since December last I have kept a regular journal of three-hourly meteorological observations,—at least, so far as my limited staff of instruments allowed me, having only a simple, but very good pediment barometer, Zambra's thermometer, and aneroid barometer. Having neither rain-guage, anemometer, or hygrometer, of course my observations are very limited; but, such as they are, they represent some interesting facts with regard to Australian meteorology.

"*Observatory, Gellibrand's Point,*
Williamstown, Victoria."

Account of the Steps recently taken by Her Majesty's Government for Promoting the Regular Observation of Meteorological Phenomena at Sea. By Capt. Robert Fitzroy, R.N.

"The importance of accumulating meteorological observations,

and tabulating them methodically, for the purpose of future, rather than immediate investigation, having been urged by the Royal Society, while the practical benefits arising from such collections, even at the present time, were proved by the direct consequences of Maury's extensive labours, Her Majesty's Ministers agreed to establish an office under the Board of Trade for receiving and tabulating all such observations made at sea.

"It was considered that much information might be compiled with respect to currents, as well as winds, which might be made more generally known to those interested in the passages of ships across the ocean; and that the sooner such authentic compilations could be made generally available, the greater would be their value. It was, moreover, pronounced to be necessary that instruments of a reliable and understood nature should be alone employed; that they should be carefully tested and vigilantly guarded from accidental causes of error.

"To meet these objects, an estimate of probable expenses was submitted to Parliament, and the sums proposed were voted, namely, 2000*l.* for the Mercantile Marine and 1000*l.* for her Majesty's ships.

"Soon afterwards an officer was appointed to execute the duties of the Meteorological Office, to be subsequently assisted by a few subordinates; but some time elapsed before instruments of the peculiar kind deemed proper by a Committee of the Royal Society could be finished, and an office appropriated for the object in view. Now the preliminary arrangements are made, and the Meteorological Office of the Board of Trade is open at No. 2 Parliament Street.

"A certain number of selected ships of the Mercantile Marine, and all those of her Majesty employed in long or distant voyages, are, or soon will be, engaged in making exact observations with instruments supplied under the authority of the Board of Trade (duly tested and compared), and in registering the apparent results according to forms settled at the Brussels Conference of 1853, slightly modified, however, so as to suit present convenience.

"The estimates sanctioned by Parliament are sufficient to provide sixty merchant-ships and forty men-of-war with the necessary meteorological instruments (namely, barometers, thermometers, and hydrometers), in addition to the nautical instruments usual at sea; to pay office expenses and salaries (including allowances to agents at outports); and to provide the necessary registers. A captain in the navy is in charge of the office. Four subordinates are to assist him, and there are agents appointed at the principal ports to communicate personally with the owners, captains, and officers of ships.

"Liberally supplied by the United States Government, Maury's Sailing Directions and Charts are distributed gratis among those who undertake to record observations satisfactorily, and send them to the Board of Trade. Marks, expressive of distinction, are to be annexed to the names of approved contributors to meteorology

in the Mercantile Navy List, and other encouragements are contemplated.

"Every exertion will be made at the office, not only to discuss and tabulate valuable observations, but to digest and render available, as soon as possible, such information as may tend immediately to the improvement of navigation.

"*February* 8, 1855."

On the Application of Photography to Astronomical Observations.

(*Letter from Sir John F. W. Herschel to Colonel Sabine.*)

"I consider it an object of very considerable importance to secure at some observatory, and indeed at more than one, in different localities, daily photographic representations of the sun, with a view to keep up a consecutive and perfectly faithful record of the history of the spots. So far as regards the general delineation of the whole disk, and the marking out on it, in reference to the parallel to the equinoctial passing through its centre, the places, sizes, and forms of the spots, there would need, I should imagine, no very powerful telescope,—quite the contrary; but it should be equatoreally mounted, and ought to have a clock motion in the parallel. The image to be impressed on the paper (or collodionized glass) should be formed not in the focus of the object-lens, but in that of the eye-lens, drawn out somewhat beyond the proper situation for distinct vision (and always to the same invariable distance to insure an equally magnified image on each day). By this arrangement, a considerably magnified image of the sun, *and also of any system of wires* in the focus of the object-glass, may be thrown upon the 'focussing-glass' of a camera-box adjusted to the eye-end of a telescope. By employing a system of spider-lines, parallel and perpendicular to the diurnal motion, and so disposed as to divide the field of vision into squares, say of 5′ in the side, the central one crossing the sun's centre (or rather as liable to no uncertainty, one of them being a tangent to its lower or upper limb), the place of each spot on the surface is, *ipso facto*, mapped down in reference to the parallel and declination circle, and its distance from the border, and its size measurable on a fixed scale.

"If large spots are to be photographed specially with a view to the delineation of their forms and changes, a pretty large object-glass will be required, and the whole affair will become a matter of much greater nicety; but for reading the daily history of the sun, I should imagine a 3-inch object-glass would be ample.

"The representations should, if possible, be taken daily, and the time carefully noted. As far as possible, they should be taken at the same hour each day; but in this climate, a clear interval, occurring when it may, had better be secured early in the day.

"Three or four observations in tropical climates, distant se-

veral hours in longitude (suppose 3, at 8^h distance in longitude), each recording at, or nearly at noon, would, when the results were assembled, keep up a continuous history of the solar disk.

"With regard to proper preparation of paper, or the use of collodion acid, the photographic art is now so much advanced, that no difficulty can arise in fixing upon fitting preparations, or the manipulations necessary for multiplying them. But it would be very requisite that many impressions of each day's work should be taken and distributed, and an interchange kept up among observers.

"*April* 24, 1854."

Observations of Comet I. 1855. By Dr. Donati.

(*Communicated by Mr. Drach.*)

	Florence M.T.	Comet—Star. $\Delta\alpha$	$\Delta\delta$	Comet's Apparent R.A.	Decl.
1855.	h m s	m s	′ ″	o ′ ″	o ′ ″
Feb. 15	17 9 8·1	+4 7·02	−17 34·0	16 30 57·37	−28 12 31·8*
	17 37 38·5	−4 55·76	+ 1 57·7	16 30 59·30	−28 12 30·3†

* 5 comparisons with *a*. † 3 comparisons with *b*.

Adopted Apparent Places of Comparison Stars.

		R.A.	Decl.		
		h m s	o ′ ″		
a	Feb. 15	16 26 50·35	−27 54 57·8	Piazzi 113	Hora xvi.
b	—	18 35 55·06	−28 14 28·0	— 159	—

The comet was very faint.

On the Constitution of the Atmosphere, upon which Laplace's Table of Astronomical Refractions is founded. By Sir J. W. Lubbock, Bart. F.R.S.

"I have elsewhere given a table showing the constitution of the atmosphere, upon which Ivory's table of refractions, and also that upon which my own table of refractions, is founded.

"I have calculated the following table from the expressions given by Laplace in the fourth volume of the *Méc. Cél.* p. 265 :—

Height in Miles.	Laplace. Pressure, inch.	Temp. Fahr.	Density.
0	29·94	32·00	1·00000
1	24·33	6·92	·85744
2	19·56	−14·14	·72283
3	15·57	32·60	·60010
4	12·31	47·24	·49114
5	9·60	60·23	·34709
10	2·54	111·21	·11743
15	·60	120·00	·02937
20	·13	139·70	·00674

"The pressures in Laplace's theory are up to the height of five miles *less* than those of Ivory or my own, so that in calculating heights by means of the barometer, Laplace's formula would give the heights rather greater; the difference would be, roughly,

At a height of	1	mile,	263 feet
—	2	.....	519
—	3	.....	749
—	4	.....	898

"The pressures in my atmosphere and that of Ivory within these limits may be considered as identical.

"The temperatures in Laplace's atmosphere diminish far more rapidly at first than in Ivory's atmosphere or mine, namely, at the rate of a degree of Fahrenheit for every 210 feet: in my atmosphere and in Ivory's they diminish at the rate of about 1° Fahr. for 350 feet.

"The density in Laplace's atmosphere is greater than in Ivory's or mine.

"The following table, which has been published elsewhere, is repeated here for the sake of comparison:—

Height in Miles.	Lubbock. Pressure. inch.	Temp. Fahr.	Density.	Ivory. Pressure. inch.	Temp. Fahr.	Density.
0	30·00	+ 50·0	1·00000	30·00	+ 50·0	1·00000
1	24·61	35·0	·84611	24·61	34·4	·84875
2	20·07	19·5	·71294	20·05	18·3	·71373
3	16·25	+ 3·4	·59798	16·22	+ 4·9	·59472
4	13·06	− 13·3	·49903	13·07	− 6·3	·49118
5	10·41	30·6	·41403	10·47	16·2	·40230
10	2·81	126·4	·14499	3·25	45·8	·13407
15	·45	240·6	·03573	·95	56·2	·04044
20	...	...	...	·28	59·4	·01175
22·35	...	−448·0	·00000			
30	...	...	...	·02	60·6	·00097

"It appears to me that accurate observations are still wanting to determine the rate at which the temperature diminishes with the altitude, and especially to decide whether the rate be greater at night than by day. This is the more important as astronomical observations are chiefly made at night. Where I reside in the country, the situation is somewhat elevated, and the climate is cold in consequence, as I believe, but the nights are much colder in proportion than the days."

Remarks on Mr. Powell's Elements of the Orbit of 70 *Ophiuchi.*

By Isaac Fletcher, Esq.

"The *Monthly Notices* for December last contain an interesting and very able discussion by Mr. Powell of the orbit of this remarkable star. So far as the agreement between the observed and computed angles of position is concerned, Mr. Powell's orbit represents, with singular fidelity, the actual path of the companion star. As Mr. Powell remarks, the agreement is less satisfactory as regards the distances, and it is on this point that I am desirous of making a few brief remarks.

"If Mr. Powell's orbit is correct, the distance of the two stars is still increasing; and Mr. Powell is of opinion that the measures of distance in existence are not sufficiently trustworthy to warrant an alteration in the elements sufficient to reconcile the great discrepancy between the calculated and observed distance for the epoch of 1854. This discrepancy amounts to $0''{\cdot}538$.

"I can hardly believe that an error of such magnitude can exist in the measured distance of so easy a star as 70 *Ophiuchi*, especially if that distance is the result of several nights' observations by so experienced an observer as Capt. Jacob. Having carefully examined all the observed distances of 70 *Ophiuchi*, I find the individual results of each observer, as well as the united testimony of all, concur in indicating an *increase* in distance up to the epoch of 1849 or 1850, since which time it appears to me there is evidence equally unequivocal of a *decrease* in that element. If this be really the fact, I think, as Mr. Powell has pointed out, a slight alteration in the position of the node, or of the periastre, would reconcile the theoretical orbit with the actual fact. As I have a pretty strong opinion that the distance is now diminishing, I beg to submit a statement of all the measures of distance I am acquainted with since 1850.

By Capt. Jacob.

Epoch	1850·571	Distance	$6''{\cdot}86$
—	1852·75	—	6·73
—	1854·081	—	6·365

"The above are taken from Mr. Powell's paper.

"In the last supplement to the *Notices*, however, Capt. Jacob's result for 1854 is thus stated:

Epoch	1854·262	Distance	$6''{\cdot}51$

Whichever value, however, is adopted, my agreement is not weakened, viz., that Capt. Jacob's measures show a decided decrease in distance.

By Mr. J. F. Miller.

Epoch	1851·64	Distance	6″·508
—	1852·71	—	6·466

The first of these results is derived from a mean of 32 measures, and the latter from a mean of 22.

By myself.

Epoch	1850·66	Distance	6″·459
—	1851·58	—	6·378
—	1852·63	—	6·362
—	1854·62	—	6·300

The first result is from a mean of 56 measures, the second from a mean of 126, and the third from a mean of 78, but the fourth is merely a single night's result, and therefore of little value.

"An inspection of the above measures shows that three different observers, working independently, have all obtained results which conspire to prove that the distance is now decreasing.

"If the distance is really increasing, it is, at any rate, extraordinary, that these results should indicate the contrary.

"In making these remarks, I am very far from wishing to cavil at Mr. Powell's elements. On the contrary, I think that his orbit is decidedly the best that has yet appeared, but I think this able computer has hardly given to the measures of distance the weight to which they are entitled. If the elements could be varied so as to represent the recent observed distances with tolerable precision, without introducing more serious differences in the angles, it would, I think, be more satisfactory.

"Mr. Powell's important researches have, however, indisputably established a fact which has been doubted in high quarters,—that the relative motions of the components of 70 *Ophiuchi do* follow the Newtonian laws of gravitation.

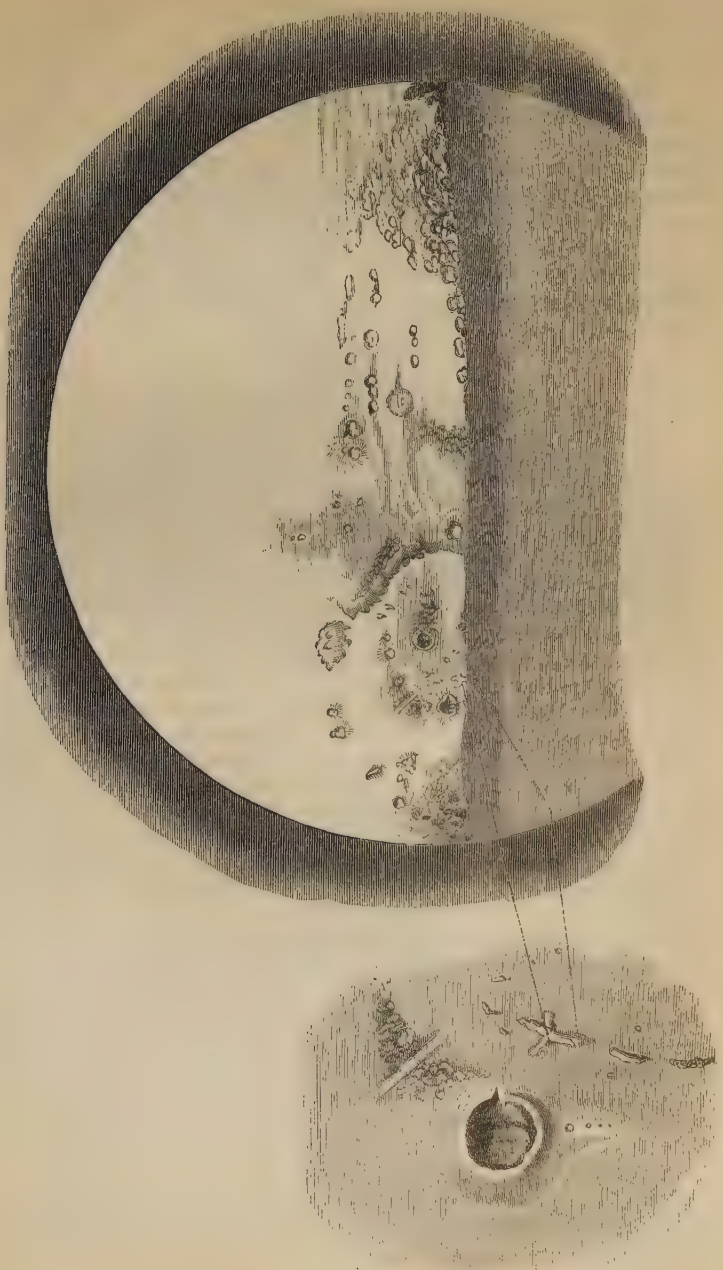
"*Tarn Bank, Jan.* 24, 1855."

On a Telescopic Appearance seen in the Moon.

By Robert Hart, Esq.

(*Extract of a Letter to the Astronomer Royal.*)

"Since I wrote you last [respecting the two fiery-looking spots in the moon's disk] I have taken every opportunity of examining the same region of the moon while it was in shadow, and also during the early part of this moon, and most carefully when she was of the same age. But there is no such appearance of any such light as was so visible on the night of the 27th December last, between 7 and 12 P.M. (the time that I observed her).



"I have made a sketch, which I enclose, of the region where they were; and again when she was two days older, and when the ridge was full in the light I made the enlarged sketch.

"I have no doubt the light was from the two small mouths shown in the angles of the cruciform ridge.* . . . In looking at the ridge, as drawn, the form of the lights is just what we should expect anything flowing from these mouths would take. If they are mouths, which I am assuming them to be, they are very small.

"My telescope is a reflector of 12 feet focal length and 10 inches in diameter, of our own making. The speculum has not been polished these twelve years, and may not show so sharp as it did at first."

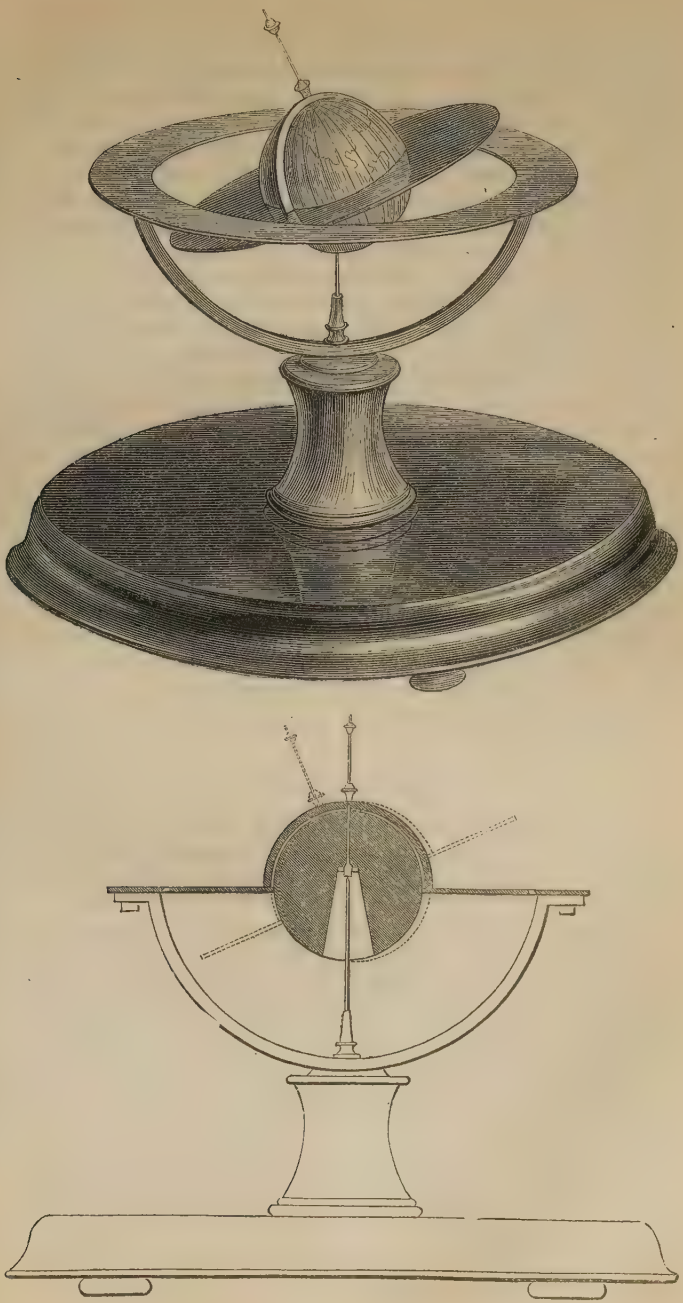
Description of an Apparatus for the Mechanical Imitation of Precession. By T. W. Burr, Esq.

"Being desirous, for educational purposes, of obtaining some piece of mechanism which should represent the motion of precession in a more tangible form than can be done by diagrams on a plane surface, my attention, while considering the subject, was arrested by a description in vol. i. page 43, of the *Monthly Notices*, of an instrument invented by Mr. Atkinson, to illustrate certain phenomena of rotation. The account is very short and not very lucid, stating that 'it consists of a flat circular disk, through the centre of which passes a small endless screw, having a cup in one of its extremities.' When this cup is set on a point, and the disk made to rotate in its own plane, the whole rotating plane performs at the same time a slow revolution round the perpendicular to the horizon which passes through the point of suspension, and the direction of this revolution will either coincide with, or be the reverse of, the rotation, accordingly, as the centre of gravity is above or below the point of suspension; affording in the latter case, says Mr. Atkinson, 'an apt illustration of precession.'

"Acting upon this suggestion, and adding such improvements as enable the instrument more effectually to represent the real state of the case, I have had the apparatus submitted to the meeting constructed.† It consists of a small terrestrial globe, having a steel axis projecting from the north pole, and the equator extended into a broad brass disk. The globe is suspended on a point, rising into its interior from a base which supports a horizontal graduated circle representing the ecliptic; and the whole

* The writer here makes a remark which is not very clear respecting the form of the luminous spots. The light on the right side would appear to have consisted of two streaks of unequal length disposed in opposite directions.—Editor.

† It was beautifully made by Mr. Hislop, chronometer-maker, 108 St. John Street Road.



being nicely balanced, the ecliptic and equator coincide. If now a small weight be fixed to the equatoreal disk, to represent the attraction of the sun and moon, or the axis be considerably inclined, which answers the same purpose, and the globe be rapidly rotated, representing the diurnal motion, it will be seen that at the same time there is generated a slow conical movement of the projecting axis round the imaginary pole of the ecliptic, in a direction opposite to that of the diurnal rotation; and that the equinoctial points, or intersections of the ecliptic and equator, move round in the same way."

The author remarks that, upon attentive observation, it will be found that the axis does not describe a perfect circle round the perpendicular to the ecliptic, but that there is a minute undulation resembling the nutation of the earth's axis.

"I am aware that the mechanical causes of the motions set up are not the same with the physical causes of the real motions of the earth, but the object was to obtain an imitation of the effect, regardless of the exact identity of mechanical causes. So far as I understand the description of Mr. Atkinson's instrument, there is, of course, an identity of principle and effect, but he seems to have had other points to illustrate, and only mentions precession as an incidental one; whereas, in my construction of the apparatus, those additions are made which enable it to carry out the imitation to the fullest extent; and having myself found it useful in explaining the motions referred to, I have thought a knowledge of it might be acceptable for a like purpose to other members of the Society. The drawings show the apparatus in perspective and section, and are sufficient, with the preceding description, to explain it without references."*

Note by the Editor.

In the *Edinburgh New Philosophical Journal* for April 1855 there is a paper by Mr. James Elliot, Teacher of Mathematics, Edinburgh, which also contains a description of an apparatus

* Apparatuses for exhibiting the conical movement of the earth's axis, which occasions the precession of the equinoxes, have also been contrived by Bohnenberger, Fessel, and Professor Powell. They are all unexceptionable, both in principle and practice, and serve to represent the phenomenon with the most complete fidelity. This remark will appear superfluous to many persons, but it has been deemed necessary to advert to the circumstance in consequence of objections having been urged against those apparatuses, which could only arise from an imperfect knowledge of the mechanical principles of their construction. Nor can such objections be justified by referring them to an imperfect working of the apparatus in any case, since from the nature of the mechanism it is impossible that the axis of rotation, if it have a movement at all, should have any other than a conical movement. In all these contrivances (as in Atkinson's original apparatus, now in the possession of Mr. Riddle at Greenwich) there is an arrangement of great simplicity, by which the conical motion of the axis of rotation may be rendered *direct*, as exemplified by the spinning-top or *retrograde*, as in the case of the earth's motion, thus affording a most instructive view of the mechanical principles which determine the grand phenomenon of the precession of the equinoxes.—Editor.

exactly the same as Atkinson's; but the author does not seem to be aware of the fact that any person had preceded him in the invention. The paper, which is entitled "A Description of certain Mechanical Illustrations of the Planetary Motion, accompanied by Theoretical Investigations relating to them, and in particular a new Explanation of the Stability of Equilibrium of *Saturn's* Rings," was read before the Royal Scottish Society of Arts on the 27th of February and 13th of March, 1854.* It contains several ingenious illustrations of the planetary movements in addition to that of precession. The author states that he was first led to consider the possibility of imitating the conical motion of the earth's axis by observing the whirling of a penny, and that afterwards, from reading Herschel's *Astronomy*, his attention was turned to the analogous movements of the te-to-tum and the top. "I observed, however," says he, "that in tops which have short pegs, this motion—the conical motion of the axis—is slower than in those which have long ones; and, in fact, the shorter the peg the slower the revolution. It therefore occurred to me, that if we could lower the centre of gravity till it coincided with the centre of motion, this movement would cease altogether, and the top would continue to spin with its axis pointing permanently in any direction in which it might be placed. I also concluded, if we still further extended the same change which gradually annihilated the positive motion, it would reappear negative or in the opposite direction. With that view I had an instrument constructed of the form showed in the annexed cut,† consisting of a wooden ball hollowed out in its lower part, so as to admit the support upon which it rests to be raised above the centre of gravity, and with a screw upon its peg or axis, to admit of its being raised or lowered at pleasure. I also confined it to one place, by forming a small cavity on the support for the point of the peg to run in. This being done, I was much pleased to find my expectations exactly realised. By adjustments of the screw the conical revolution could be quickened, retarded, annihilated, or reversed, as might be desired, and all its motions were brought under perfect control. At the same time it was surrounded by a fixed plane to represent the ecliptic, its own equator being marked upon it; and by forming the axis of hard steel and giving it a support of agate, its velocity could be kept up without much abatement for a long time.‡

"The rotation is produced in the ball by means of a string and handle, much in the same way as that in which a humming-top is spun. The case in which, from the two centres coinciding, the axis remains fixed in one direction without any conical revolution,

* It is stated that the silver medal of the Society, value ten sovereigns, was awarded to the author on account of his paper.

† The drawing here alluded to is almost identical with that annexed to the preceding paper.

‡ The author here states in a note, that since the model described was constructed, his attention had been directed to Bohnenberger's instrument, of which he was not previously aware.

enables us to illustrate clearly what is meant in astronomy by the parallelism of the earth's axis, since the model may be carried by the hand slowly round in any circular or elliptic orbit, without any perceptible deviation of the axis from its original direction. But when the centre of gravity is brought slightly below the point of support, we are then enabled to show the deviation from parallelism which arises in the direction of the earth's axis after a long period of years, the same motion exhibiting the precession of the equinoxes. With the centre of gravity so placed, if the ball is made to rotate in the direction marked by the upper arrow on the figure, or from west to east, the equinoctial point E is observed to move slowly in the direction marked by the lower arrow from east to west. The latter motion may be made as slow as we please, so as to approach within any degree of closeness the exceedingly slow precessional movement of the earth's equator."

In another part of his paper the author makes the following remark:—

"If we next load the sphere on one side *very slightly* by any means, we obtain an illustration of the nutation of the earth's axis, the axis making a multitude of minute conical revolutions round the circumference of the greater conical revolution."

Note on the Method of Computing the Moon's Parallax.
By Mr. Sang.

In deducing the true from the apparent place of a heavenly body, it is usual to correct the observed altitude for the effect of atmospheric refraction, and to use the altitude thus corrected as the argument for the parallax; the sine of the parallax being supposed to be proportional to the sine of the corrected zenith distance.

This operation is founded on the hypothesis, that on correcting the observed altitude for refraction we obtain that altitude at which the planet would have been seen from the observatory if there had been no atmosphere. This hypothesis, however, is incorrect, as is evident when we consider that the ray of light, impinging on the upper surface of the atmosphere, is gradually bent downwards, and reaches the eye after having traced a curved path through the air. The angle of refraction is that angle which the first direction of the light makes with its direction when just entering the telescope; and, therefore, on correcting the observed altitude for refraction we obtain the direction, not of the original unrefracted ray, but of a line drawn parallel to it through the place of observation, which line cannot pass truly through the planet.

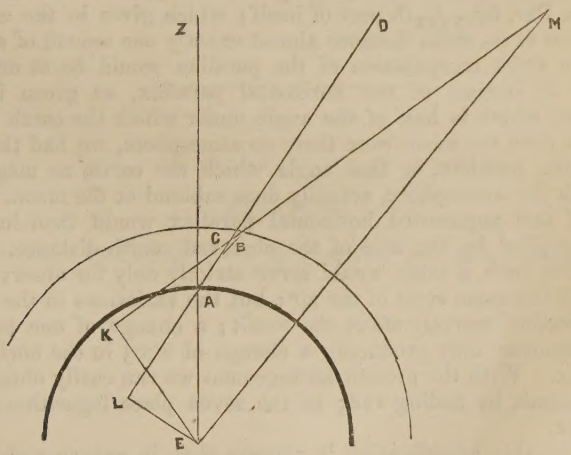
Thus if A be the observatory on the earth's surface, M the position of a celestial body, and M B the ray of light entering the atmosphere at B and then describing the curved line B A, the

line A D drawn to touch that curve at A gives the apparent position of the planet; and if we continue M B to meet the tangent in C, M C D is the angle of refraction. When, therefore, we add the refraction D C M to the observed zenith distance Z A D we obtain the zenith distance of a line drawn through A parallel to C M; and this corrected zenith distance exceeds that which the planet would have had if there had been no atmosphere by the angle A M B, under which the curved path B A would be seen from the planet.

In the case of the primary planets this angle A M B is much too small to be taken into consideration, but in the case of the earth's satellite it may possibly amount to something appreciable. My object in the present paper is to estimate the amount of error caused by neglecting this angle.

At first it would seem that for this purpose we must know the nature of the curve B A; and that thus all the uncertainties which perplex us in regard to the gradual attenuation of the air would complicate our inquiry. But, fortunately, it turns out that these considerations are eliminated, and that the strict computation of the parallax is more simple and more direct than the ordinary approximate computations.

Having joined M with E, the centre of the earth, E M B is the true parallax. Continue M B and D A to meet perpendiculars let fall upon them from E. Then it is a well-known property of rays refracted by concentric strata that the ratio of these perpendiculars E K and E L is that of the indices of refraction of the strata at B and A inversely.



Now the index of refraction of the air at A can be obtained by direct experiment, or can be computed from the states of the barometer and thermometer, so that the ratio of E K to E L is known. Let this ratio be denoted by i.

Then we have

$$\sin \mathrm{EMK} = \frac{\mathrm{EK}}{\mathrm{EM}} = i\frac{\mathrm{EL}}{\mathrm{EM}} = i\frac{\mathrm{EA}}{\mathrm{EM}} \sin \mathrm{ZAD}.$$

But $\frac{\mathrm{EA}}{\mathrm{EM}}$ is the sine of the moon's horizontal parallax, on the supposition of there being no atmosphere; and, therefore, it appears that the sine of the actual parallax is obtained by multiplying the sine of the horizontal parallax by the sine of the observed zenith distance and by the index of refraction of the air.

The true argument for parallax is thus the observed, and not the corrected, altitude, the formula being

$$\sin \text{par.} = i \,.\, \sin \text{Hor. Par.} \,.\, \sin \text{app. Zen. Dist.}$$

On comparing this formula with the usual one, we find that the coefficient *sin corrected Zen. Dist.* has been replaced by *i . sin observed Zen. Dist.;* these two coefficients would be identical if the strata of the atmosphere were plane instead of spherical, so that the true computation must give a result differing more and more from the usual one as the angle AEB becomes larger, and we may expect the greatest deviation to be when the moon is in the horizon. When the apparent zenith distance is 90° the corrected is about 90° 33′, and the sine of the corrected zenith distance, instead of being greater, is actually less than that of the apparent. For the purpose of roughly estimating the inaccuracy of the common formula we may take these sines as equal to each other; now the index of refraction of air at its mean density is $\frac{3405}{3404}$ nearly; and, therefore, for planets apparently on the horizon, the parallax exceeds that quantity which is given in the almanacs as Hor. Par. by $\frac{1}{3404}$th part of itself; which gives in the case of the moon at its mean distance almost exactly one second of arc.

The strict computation of the parallax would be at once effected, if, instead of the horizontal parallax, as given in the almanac, which is half of the angle under which the earth would be seen from the moon were there no atmosphere, we had the true horizontal parallax, or that angle which the earth, as magnified through the atmosphere, actually does subtend at the moon. The sine of this augmented horizontal parallax would then have to be multiplied by the sine of the observed zenith distance. It is true that such a table would serve strictly only for observations made in the mean state of the air; but the variations in the index of refraction scarcely affect the result; a change of one inch in the barometer only producing a change of 0″·03 in the horizontal parallax. With the present arrangement we can easily obtain the strict result by adding 1285 to the seven place logarithm of the parallax.

From this investigation it appears that, in reducing observations made on the occultation of fixed stars by the moon, it is scarcely necessary to take the actual amount of refraction into account at all: at most, in observations on moon-culminating stars, the differential refraction is required.

Waarnemingen gedaan te Manado ter bepaling van de Geographische lengte dier plaats, door S. H. De Lange en G. A. De Lange, Geografische Ingenieurs.

(*Communicated by the Astronomer Royal.*)

In the *Monthly Notices* for December last a brief account was given of a series of astronomical operations by the author of this paper, S. H. De Lange, in conjunction with his colleague, G. A. De Lange, having for their object the determination of the longitude of Batavia, chiefly by observations of the zenith distance of the moon. The most important feature of these operations consisted in the mode in which the zenith distance of the moon was determined. This was effected by first observing the moon, and then turning round the telescope in azimuth without unclamping it, so as to bring the star of comparison into the field of view. The operations for determining the longitude of Manado appear from the paper communicated on the present occasion to be precisely similar to those employed in the case of Batavia. The author, however, remarks, that the individual results are not so consistent in the present case,—a circumstance which he is inclined to attribute to the exposed situation of the telescope, and its consequent liability to be shaken by high winds. In reducing the observations of the moon's zenith distance, Adams's correction of the moon's parallax was employed. The observations extend from May 28, 1852, to January 21, 1853. As in the former paper, no definitive value of the longitude is given.

ERRATUM.

Page 49, line 2 from top, *for* Lieut. G. M. Gilliss, *read* Lieut. J. M. Gilliss.

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